Proceedings of the Second International Conference on Inventive Research in Computing Applications (ICIRCA-2020)
IEEE Xplore Part Number: CFP20N67-ART; ISBN: 978-1-7281-5374-2

Automated Shopping Cart Using RFID with a Collaborative Clustering Driven Recommendation System

[1]Ruchi Gupte, [2]Shambhavi Rege, [3]Sarah Hawa , [4]Dr. Y S Rao , [5]Dr. Rajendra Sawant
[1,2,3,4,5]*Sardar Patel Institute of Technology, Bhartiya Vidya Bhavan's Campus, Andheri, West Mumbai, India*
[1]*ruchi.gupte@spit.ac.in,* [2]*shambhavi.rege@spit.ac.in,* [3]*sarah.hawa@spit.ac.in,* [4]*ysrao@spit.ac.in,* [5]*rajendra.sawant@spit.ac.in*

***Abstract*—Recent advancements in technology have seen a significant reduction in human intervention. New technologies are introduced to replace outdated conventions where emphasis is put on the incorporation of Artificial Intelligence and Automation in our daily lives. With the current COVID-19 pandemic, reducing human interaction in everyday actions has now been deemed necessary. One of the most important sectors affected, the shopping industry, needs to adapt to meet government and social security standards. This paper addresses a Smart Shopping Cart System where the entire shopping experience is automated and handled by the customer. It details a more efficient online mode of shopping which not only reduces the need for hands-on staff but also provides specialized recommendations to users using collaborative clustering to update the shopping experience and meet the demands of our time. The current shopping system has many limitations, and introduction of Radio-frequency identification (RFID) technology as the core identification mechanism can prove useful for applications such as security, safety and inventory management.**

***Index Terms*—Key Words: Smart Shopping Cart; RFID; Collaborative Clustering; Artificial Intelligence; Automation; COVID-19.**

I. INTRODUCTION

CURRENTLY, most department stores use a simple barcode which is scanned and operated by store staff at specific locations within the store. The barcode system runs on laser technology, which needs the product to be in the line of sight of the scanner to be scanned one at a time whose scanning range is only a few inches, making the system inefficient and tedious. Barcodes require manpower which not only consumes a lot of time and effort but also requires the customers to stand in a long queue. With the COVID19 outbreak, it has become increasingly necessary to reduce crowds and speed up essential service processes. Barcode systems not only provide little help in this respect but also lack the ability to provide extra support to the existing shopping system during this crisis. Barcodes cannot be used to track products in real-time as the optical technology required to scan it is extremely short range and thus cannot be used for security applications. They can be easily tampered with and cannot be used as efficiently for automated shopping systems.

Our proposed system is an Automated Shopping Cart using Raspberry Pi and (Radio-frequency identification) RFID that eradicates the need for long queues, reduces the manpower and makes the management system much easier and efficient for the customers. The proposed device shall be installed on the shopping cart and the customer can scan their products themselves and at the end of the shopping, and a bill can be generated on the users and application. Here the customer can also make the required payment via a payment gateway linked to the application and can also provide recommendations based on the purchases that they make. The scanned product details will be updated on the database maintained by the retailer, allowing the shopkeeper to perform sales analytics to maximize their sales profit. RFID tags can be scanned at long range and can thus be integrated with security to provide an extra anti-theft measure. The incorporation of all these components is necessary to providing a complete experience while still increasing the store's efficiency and security.

A. Industry Standards

Standards are critical for many RFID applications, such as payment systems, inventory management, railways. ISO and EPCP global are two bodies that standardise and specify RFID components.

TABLE I
INDUSTRY STANDARDS

RFID Standard	Field
Audio Id tag	Standard class 2
ISO 16963	Item management
ISO 18000-V3	13.56 MHz interface

The proposed design is much more functionally efficient than the existing models in the industry. Traditional RFID readers are not used widely and the number of self-checkout services use bar-codes as the ID. Barcodes do not provide the same security as RFID and do not allow for additional features such as real-time product tracking and inventory management. The RFID scanners used in shops are handled mainly by the cashiers and they are not designed to ensure specialized user experience. The Artificial Intelligence Recommendation Systems for shopping that exist do not function real-time and do not have a system in place that handle the shopping as well as the recommendations at a time [6]. Thus while individual technologies do exist in the domain, no product provides a comprehensive complete experience to the shopkeeper and the user.

B. Literature Survey

The implementation of RFID technology is growing at an exponential rate and the use of such a technology in shopping carts is bound to improve customer experience along with simplifying the process of billing. Research has seen the use of RFID and Zigbee along with an application that creates an automated central bill system for the mall [2]. Customers can pay their bill through credit/debit cards. The bill of the user is stored on a local database and a constant log of the purchases can be kept and analysed when needed along with detailed interfacing with peripheral devices such as Zigbee, LCD and a micro controller [6] [13]. Such Smart Billing systems allows users to add items in the cart and upload them in an online application that can be paid for using online wallets [8] [1]. Here, each user carries a membership card and swipes it on the sensor in the cart, allowing the shop items to be uploaded to the users account on the application and each Trolley contains an RFID scanner along with a Zigbee module. Through these modules, the user data is uploaded.

In other projects, a Raspberry Pi module is used, which allows the users to upload the data and host it on an online platform, allowing users to pay for their items through an online wallet and monitor the contents of their cart [4]. However, in the existing systems, there are no user recommendations on the other similar products available in the store according to users shopping history. There is no online database that tracks and keeps logs of all of the user's transactions. The products are not classified to predict trends in sales. In the case where Zigbee and micro controllers are used, the product did not store the data on the cloud, but on a local device in the shop which does not allow users to connect their mobiles to the system.

It is also observed that the most of the proposed systems will only allow the user to access their bill through the LCD screen, and thus, the payment via Mobile wallets and cash is difficult and therefore there is more exposure to theft and no features to prevent burglary and tampering. Thus from our literature survey, it is realised that while these ideas work and can be easily implemented, they may not be secure and may not provide a complete user experience. This shortcoming can be overcome by uploading the data to the cloud, allowing us to manage many users and also securely store the data along with multiple backups. By using a Raspberry Pi and integrating the product with a mobile application, the user will be allowed to easily view and complete billing on their mobile device and provide shopping suggestions based on their purchase history, giving a more all-rounded user experience. The constant logs of the devices sold are kept, thus the user trends can be checked in the sales.

C. Objective

The main objective of the above project is to demonstrate the incorporation of RFID technology and Artificial Intelligence in shopping carts which will not only make the billing easier but will also improve customer experience. It has been planned to place this product in the shopping cart and as a customer adds a new product, the online user cart is updated and the total amount is displayed. To remove the product, the customer will have to scan the RFID tag of the product again. The motive of this innovative system is to make shopping more comfortable and organised for the customer as well and the owner of the store as it is much easier to track and manage products with the help of the database which gets updated every time a product is added to the cart or purchased. A customer product recommendation feature introduces a complete user experience and gives the customer a more specialized service which was previously limited only to online shopping. Through this, it can integrate the benefits of online retail with the existing offline industry and thus bring forth a much needed change in the modern shopping experience [4].

II. Hardware And Technologies Used

In our Smart Shopping cart, the hardware essentially consists of Raspberry Pi and the RFID, with NO-SQL used for database management.

A. Raspberry Pi

The Raspberry Pi is a low priced, credit-card sized computer which is optimal for complex Internet of Things solutions. The in-built Wi-Fi module reduces the need for interfacing a separate module and its various pins allow us to interface multiple peripherals to the product. The micro controller that has been used is Raspberry Pi 3. The coding is done in an environment that makes Raspberry Pi communicate through Wi-Fi. Having a high processing speed and capability allows for artificial intelligence applications to be included in the proposed system and allows fast and efficient transactions and facilitates and optimized user experience.

B. Radio-frequency identification

RFID typically makes use of radio waves to read in the information via an RFID tag. The RFID tag consists of a microchip for processing and storing data, and an antenna for transmitting and receiving the radio frequency signals [11].

C. No-SQL

An Android application is used by the end-user. The store will have a database of all the items that are available. The application, uses a No-SQL real-time database to store each users cart items. Every user has a separate node and each node comprises of sub-nodes. When the item is scanned, the unique code will be compared with the stores existing database and once found, the item will be reflected in the cart on the mobile application of the user.

III. Implementation

A. User Flow

This section has implemented a shopping cart, which has an inbuilt scanning unit which consists of an RC522 RFID Reader, a Raspberry Pi 3 micro controller, an LED indicator and a battery module. In the proposed system, an RFID tag is attached to every product in the shop's inventory. When the customer decides to purchase an item in the shop, they can

physically scan the RFID tag of the product using the scanning unit attached to the shopping cart. The reader will relay the information to the Raspberry Pi 3 which will update the price and the description of the product on the user's application via the internet. This is possible due to the Raspberry Pi's inbuilt Wi-Fi module which would be connected to the stores hotspot. This process is shown in the Fig 1.

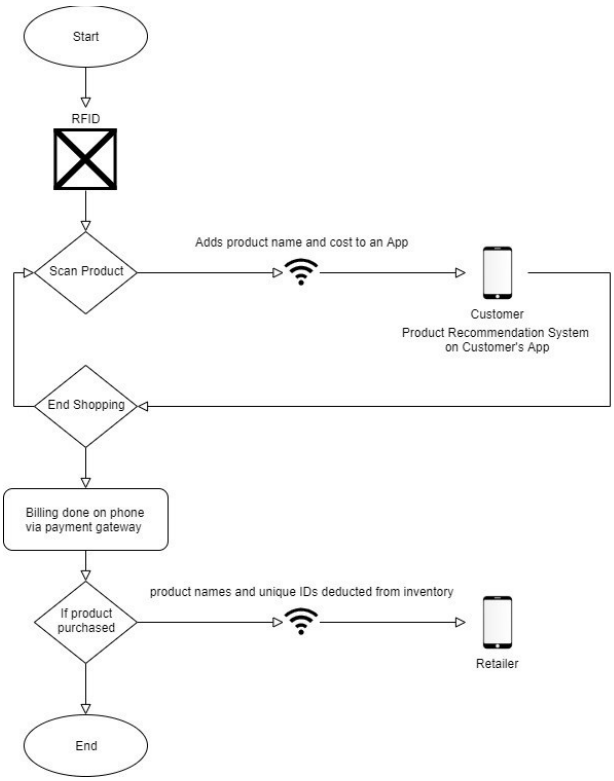

Fig. 1. Flowchart for the working of the system

The system also provides the customer with recommendations based on their purchases. These recommendations are made based on similar products to those purchased by the customer, similar preferences of other customers and the preferences of the customer. The customer can update the cart with the items they wishes to purchase and can view the updated bill of items on the application. After the customer has confirmed the purchase a bill is generated by the system, it is paid for by the customer via payment gateway which is linked to the application. When a set of items are purchased by the customer, there is an update made in the database maintained by the retailer with the help of a NO-SQL real-time database. Through this mechanism, an inventory database is maintained by the retailer.

B. Security

An anti-theft measure also forms an important part of the proposed system [1]. A high powered RFID reader at the exits of the store scans the RFID tags before the customer exits. It is tallied with the inventory database which keeps track of purchased products in real time. Thus, alarms and security modules can be installed by the shopkeeper at the exit as an anti-theft measure. Since the model works in real time, if a scanned item has not been purchased yet, an alert can be sent to security or the stores alarms could be triggered to indicate a potential case of theft.

C. Collaborative Clustering Recommendation System

The data set used for training our recommendation system is the SNAP"Web data: Amazon reviews" which contains 35 million reviews from Amazon. The data span a period of 18 years up to March 2013. The data set contains ratings, plain text reviews, product and user information such as related products, brand info and buyer history [10]. The system recommends items to users based on purchase history and similarity of ratings provided by other users who bought items to that of a particular customer. A model-based collaborative filtering technique is chosen here as it helps in making predicting products for a particular user by identifying patterns based on preferences from multiple users [9].

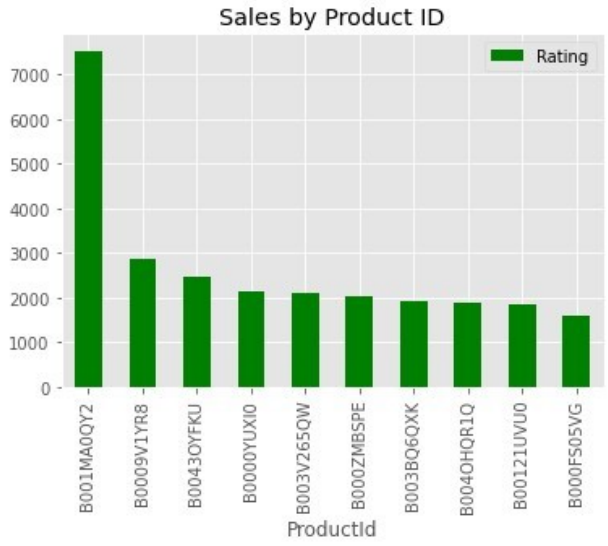

Fig. 2. Bar graph of the most popular products sold by the business

By using K-Means Clustering, it has been able to detect communities of products that occur together and also figure out the correlation between any two products, thereby providing relatively accurate suggestions to a user who is shopping. The graph in Fig 2 gives us the sales of the most popular products (arranged in descending order). For example, product, ID B001MA0QY2 has sales of over 7000, the next most popular product, ID B0009V1YR8 has sales of 3000. The popularity of a certain product can be combined with the recommendation system to suggest alternatives to the customer.

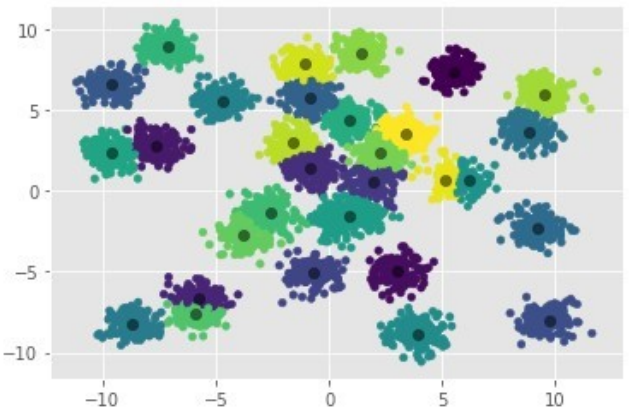

Fig. 3. Bar graph of the most popular products sold by the business

Using shopping history data from the Amazon data set, the proposed model has performed K-means collaborative clustering to obtain unique clusters of words and items that go together. As shown in Fig 3 the different clusters have been detected using the data set, with each cluster representing a group of words/products that occur frequently together, giving a list of items with a high probability of being purchased together by a certain user. The darker data point in each cluster indicates the cluster centres found.

When a current user is shopping with certain products in the cart, the model is able to recommend other products that occur in that cluster i.e. the products that are usually purchased together and have a high chance of being bought by the user. After testing the model by giving current user items as input, the model was recommending seemingly appropriate related items as the result. By setting the number of clusters to 30, it gains the ability to get an optimal clustering model to recommend related products from a variety of possible options. This clustering model implemented should be able to

D. Application Interface

The given application displays the number of items that have been added in the cart in real-time and then calculates the bill total at the end. When an item is scanned by the RFID reader in the shopping cart, the Raspberry Pi inputs the RFID unique code and sends this to the server. The unique code corresponds to the item that has been added. Fig 4 demonstrates a simple user interface to shop for items and a recommendations page which suggests products based on the user's purchase history. The Application works in tandem with No-SQL Database, where all the user data and product information is present. Each unique RFID code will correspond to an item, as well as its specialised characteristics to help the Collaborative Clustering Recommendation System generate a suggested items list for the person. When a certain item is scanned, the No-SQL Database has an account of that product and returns the details to the module. Then this data is sent to the application where it is updated. The Recommendation System will be located as an option at the bottom half of the cart application and at the checkout page during billing.

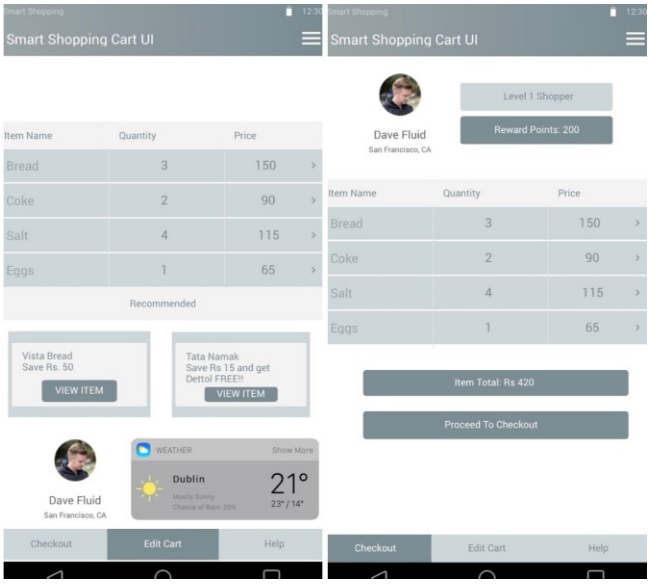

Fig. 4. User Interface

The key highlights of our User Interface are product recommendations that are suggested to the user along with a payment gateway for a smoother and hassle free transaction.

E. Prototype

The Shopping Cart prototype in Fig 5 was made using Tinkercad, a free online 3D modelling program by Autodesk. It consists of a Raspberry Pi, RC522 RFID Reader, Battery Module and a LED indicator. The model uses some inbuilt Tinkercad components for the 3D representation such as the Raspberry Pi and the RC522. The dimensions of the prototype are 334mm x 487mm x 225mm, which are the dimensions of a standard 28 litre shopping basket. Since Raspberry Pi has an inbuilt internet module, extra connections and external components are not required. The battery module powers up the Raspberry Pi and can be recharged at regular intervals. When an item is scanned, the LED indicator would be programmed to light up to indicate a successful addition to the cart.

The Raspberry Pi, RC522 RFID Reader, Battery Module and a LED indicator are all attached to the side of the shopping cart in a compact module. While the prototype includes the cart itself as part of the prototype, the compact module can be fitted on any standard shopping basket according to the shop owner's preference. The RFID reader is partially made visible to the user of the shopping cart to scan the given items and add them to their cart. The items to be scanned consists of passive RFID tags which will be read by the shopping cart RFID Reader and the shop would have security bars at the exit to ensure no theft takes place which will react to unpaid RFID tags.

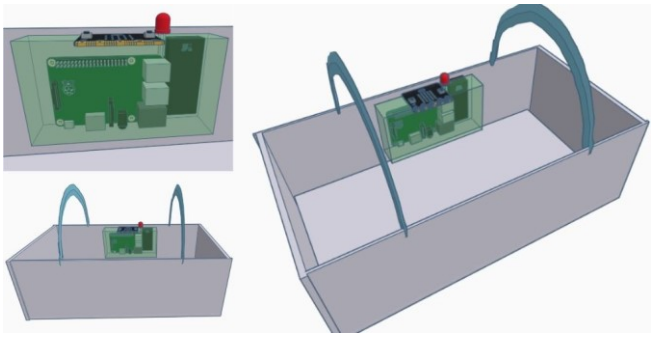

Fig. 5. Prototype Model

IV. FUTURE SCOPE

The proposed system consists of RFID tags, which could be replaced with RFID stickers, making the system much more cost-effective. An image processing algorithm could be added to reinforce the current system that would use machine learning to update the product details in the application when captured through a camera. The recommendations system currently is trained using one data set and could be further improved by making the model adaptive to further improve accuracy and effectiveness. It could also have an extra added function for providing a route to the product in the store [5]. This proposed system could expand to fully offline stores where there is no need for staff while still ensuring safety and security. Since each product is being monitored in real-time, the store has an extremely accurate inventory statistics, making it easier for them to add or integrate an online shopping system to their store without the need to restructure their shopping system [3]. With RFID tags getting cheaper, more compact and commercially viable, could cause a shift from the traditionally used barcodes to RFID as a standard means of identification.

V. CONCLUSION

This project has successfully made use of a comparatively newer and cutting edge technology such as the RFID in shopping carts to provide a holistic shopping experience while reducing the needs for hands-on service in stores. It will reduce the waiting period at billing counters and also provides safety features which will ensure that there is no theft or shoplifting thus making it a more trustworthy and reliable product for the store owner. In addition, the collaborative clustering for the recommendation system converged successfully and provided satisfactory results for an input purchase item. Thus the RFID Automated Shopping Cart proved to be a reliable and convenient alternative for existing systems which will benefit not only the user but the shop owner as well.

REFERENCES

[1] B. Chaure and P. Jain, "Development of e-shopping cart with theft control mechanism: No queue," 2016 International Conference on Emerging Technological Trends (ICETT), Kollam, 2016, pp. 1-5, doi: 10.1109/ICETT.2016.7873753.

[2] P. Chandrasekar and T. Sangeetha, "Smart shopping cart with automatic billing system through RFID and ZigBee," International Conference on Information Communication and Embedded Systems (ICICES2014), Chennai, 2014, pp. 1-4, doi: 10.1109/ICICES.2014.7033996.

[3] R. Singh, S. Verma and M. Kriti, "RFID and IR based Smart Shopping Mart Management System," 2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida (UP), India, 2018, pp. 536-540, doi: 10.1109/ICACCCN.2018.8748820.

[4] K. P. Vidya et al., "Virtual Cart: Novel Approach for Revamping Smart Shopping Experience," 2018 IEEE Distributed Computing, VLSI, Electrical Circuits and Robotics (DISCOVER), Mangalore (Mangaluru), India, 2018, pp. 135-140, doi: 10.1109/DISCOVER.2018.8674117.

[5] H. Chiang et al., "Development of smart shopping carts with customer oriented service," 2016 International Conference on System Science and Engineering (ICSSE), Puli, 2016, pp. 1-2, doi: 10.1109/ICSSE.2016.7551618.

[6] P. Li, G. Zhang, L. Chao and Z. Xie, "Personalized Recommendation System for Offline Shopping," 2018 International Conference on Audio, Language and Image Processing (ICALIP), Shanghai, 2018, pp. 445449, doi: 10.1109/ICALIP.2018.8455252.

[7] N. M. S. Iswari, W. Wella and A. Rusli, "Product Recommendation for e-Commerce System based on Ontology," 2019 1st International Conference on Cybernetics and Intelligent System (ICORIS), Denpasar, Bali, Indonesia, 2019, pp. 105-109, doi: 10.1109/ICORIS.2019.8874916.

[8] Y. Berdaliyev and A. P. James, "RFID-Cloud smart cart system," 2016 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Jaipur, 2016, pp. 2346-2352, doi: 10.1109/ICACCI.2016.7732405.

[9] S. Kaushik, "An Enhanced Recommendation System using proposed Efficient K Means User-based Clustering Algorithm," 2018 International
Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida (UP), India, 2018, pp. 251-255, doi: 10.1109/ICACCCN.2018.8748693.

[10] Jure Leskovec and Andrej Krevl, SNAP Datasets: Stanford Large Network Dataset Collection, http://snap.stanford.edu/data, June, 2014

[11] R. Want, "An introduction to RFID technology," in IEEE Pervasive Computing, vol. 5, no. 1, pp. 25-33, Jan.-March 2006, doi: 10.1109/MPRV.2006.2.

[12] Y. Wang and C. Yang, "3S-cart: A Lightweight, Interactive SensorBased Cart for Smart Shopping in Supermarkets," in IEEE Sensors Journal, vol. 16, no. 17, pp. 6774-6781, Sept.1, 2016, doi: 10.1109/JSEN.2016.2586101.

[13] R. Li, T. Song, N. Capurso, J. Yu, J. Couture and X. Cheng, "IoT Applications on Secure Smart Shopping System," in IEEE Internet of Things Journal, vol. 4, no. 6, pp. 1945-1954, Dec. 2017, doi: 10.1109/JIOT.2017.2706698.